

A NEW ENDOPARASITIC COPEPOD: MORPHOLOGY
AND DEVELOPMENT.

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(Plates lxviii. lxx.)

Introduction.—The parasitic copepod herein described occurs, as far as is yet known, only in *Ptychodera australis* Hill, and in the genital ridges thereof. The Enteropneust has only been recorded from the type-locality, that is, the coast of New South Wales, a few miles north of Port Jackson.

For my material, I have to thank Professor J. P. Hill. It comprises entire specimens and serial sections, some of the latter *in situ* in the host. The fixation is exceedingly good in most of the specimens, and the staining all that could be desired, so that, for any imperfections in the description, I alone am responsible.

This material was given me in 1905; the long delay which has occurred has been due to want of detail of the structure of certain of the appendages. After many fruitless trips in search of further material, on the part of myself and friends, in desperation I dismounted some of the whole specimens, and after treating them with one per cent. aqueous solution of sodium hydroxide, obtained from the clarified exoskeleton floating in glycerine the required details; the pictures so obtained were checked by subsequently cutting the exoskeleton along the length dorsally, so that it could be flattened out, and examined with an oil immersion, so small and flexible are the appendages that nothing short of such high magnification gave one faith in one's observations. The appendages as seen under the oil (Reichert, $\frac{1}{1\frac{1}{2}}$) were traced with the camera lucida.

U B I U S, gen. nov.

A genus of Copepod crustaceans typified by *U. hilli* (*postea*), closely allied to the monotypical genus *Ive* Mayer(5), but differing

from that in the possession of a paired ovary, the absence of a chitin-lined "end-gut," and great reduction of the nervous system. Type, *U. hilli* Kesteven.

UBIUS HILLI, sp. nov.

External Features.—Form cylindrical, more or less abruptly truncated anteriorly, and tapering to a point; bifid in the male, posteriorly (Fig. 4). The size is variable; following are the averages of six measurements: female 6.4 x 0.8; male 2.6 x 0.4 mm. If the diameter be taken as the unit of measurement, then, with fair constancy, the length of the female is eight, and that of the male six. In living specimens, the length was probably greater and the diameter less, since longitudinal body-muscles are alone well developed, and must have contracted when the animals were killed.

Colour opaque white.

Cuticle thin, very flexible, and showing very fine, closely set, annular hair-like thickenings.

External apertures: the mouth (Fig. 2) is situated ventrally, almost at the extreme anterior end. Anus absent. The vulvæ are situated ventrally on either side of the mid-line, well towards the posterior end; each is surrounded by three laterally compressed jointless appendages, two on either side of, and one directly behind the orifice (Fig. 3).

The appendages (Fig. 2) number five pairs; two are situated immediately in front of the mouth, the remainder equidistant behind it; the fifth pair being situated almost at the junction of the anterior and middle thirds of the length of the body.

The antennules (Fig. 5) are short and flattened, composed of a single segment, and provided with a toothed cutting inner edge. The musculature is composed of two bands of striated muscle, which arise from an endoskeletal cuticular rod above, and are inserted well towards the distal extremity of the appendage.

The antennæ (Fig. 6) are three-jointed chelæ, the first segment short and broad. The arrangement of the musculature is shown in Fig. 2. The third pair, mandibles (Fig. 7), are two-jointed, the first joint short and stout, the second flattened, of triangular outline, but with the apex notched; the musculature of these is also

shown in the same figure. The fourth and fifth pairs (Fig. 8) are exactly alike; they are biramous, the protopodite of one segment is broad and short. The endopodite, also unisegmented, is flattened, and has all the appearance of being chelate, but no joint is present. The exopodite is chelate, of two segments; superficially it bears a close resemblance to the endopodite. These appendages are doubtless legs.

With the exception of a slight constriction, not always present, between the third and fourth pairs of appendages, there are no indications of segmentation whatsoever.

The appendages present striking peculiarities, which has called for special care in their description. Difficulty has been caused, too, by their flexibility, so that though, between thirty and forty specimens have been examined, only in three are the second pair clearly discernible; whilst, in four of the specimens only, does one see the third pair clearly. The first, fourth, and fifth pairs are clearly visible in some eight or nine specimens.

In the absence of any evidence to aid me, I have adopted Mayer's names for the appendages (*l.c.*).

Body-Wall.—Beneath the cuticle is a syncytial (?) flattened epithelium, difficult to make out on account of its delicacy. Deep to the epithelium are the longitudinal muscle-bands; each of these is composed of three or four plain muscle-fibres, as seen in transverse section. There is apparently no anastomosis of these muscle-strands.

Perforating the body-wall are the ducts of numerous excretory (?) glands. Each gland is composed of several large, flask or spindle-shaped cells, whose cytoplasm is very granular, and whose nucleus is relatively small, and poor in chromatic material, with one well defined nucleolus. The "duct" is formed by the fusion of the necks of the component cells, and in its wall are several intensely staining granules resembling *cocci* in size and shape (Fig. 17). There is no true duct formed, the condition being rather, a group of unicellular glands perforating the body-wall by a common aperture. Similar glands are described in *Ive balanoglossi* by Mayer. These glands are most abundant anteriorly.

The body-cavity (hæmocœl) is more or less filled by branched, connective tissue cells, in some places more so than others. Corpuscles of two kinds are present in the cœlomic fluid; small, spherical, hyaline corpuscles about 3μ in diameter, with intensely staining nucleus, and larger forms with more opaque cytoplasm and vesicular nucleus, and varying in size from 8 to 15μ . These latter are irregular in outline, and are probably amœboid.

From place to place along its length, the alimentary canal is slung to the dorsal and ventral body-wall by bundles of clear fibres of some thickness (about 1μ), which closely resemble plain muscle-fibres, but are devoid of nuclei.

Alimentary Canal.—Within the mouth is a small chitin-lined, buccal cavity (Fig. 15), from which the œsophagus passes directly dorsad (Fig. 2), to the centre of the body, and there opens into the digestive tract, which, divided by three constrictions into four compartments, extends backward in a straight line through the trunk, and ends blindly a short distance posterior to the genital apertures (Fig. 1).

Immediately within the oral aperture is a sphincter muscle, and radiating to the body-wall and endoskeletal rods previously mentioned are six strands of muscle, constituting together a dilator oris. These muscles are striated (Fig. 2).

The œsophagus is lined by a columnar epithelium, whose component cells are, for the most part, completely hyaline, some, however, having granular cytoplasm (Fig. 16).

The general arrangement and relative size of the various compartments is sufficiently evident from the diagram (Fig. 1) and transverse sections (Figs. 20 to 25); it remains to describe the epithelium lining it, and a peculiar digestive(?) gland secreting into the second compartment.

The anterior portion of the first compartment is lined by an exceedingly irregular epithelium, depicted in Fig. 19. The cells, of extremely variable size, have a very granular cytoplasm, the granularity being variable. The largest granules (zymogen) are found in the enlarged bulbous ends of the larger cells, and are apparently shed by actual abstriction, since structures precisely similar to the

enlarged ends just mentioned, are found free in the lumen of the gut. This calls to mind the secretion from the digestive glands of Molluses and Crustaceans as described by MacMunn(4); and the histological resemblance between the epithelium here, and that of *Limax*(*l.c.*), is doubtless correlated with similarity of function. This epithelium recalls that of *Lernæa branchialis* Linn., as described by A. Scott(7).

The remainder of the digestive tract is lined by a minutely granular, squamous epithelium, which, however, becomes cubical and even columnar at the constrictions. The continuity of the epithelium on the dorsal wall of the second compartment is broken by the orifices of a cluster of elongated, cylindrical, unicellular glands; in fact, so numerous are these, that it would be as correct to say that they constitute the dorsal epithelium in this situation. The form of these cells is depicted in Fig. 26; their cytoplasm is finely granular, and their nuclei, as in the cells of the subdermal glands, appear disproportionately small.

The blind termination of the digestive tract is succeeded by a fibrous strand, the remnant of an aborted rectum.

In the absence of a fully developed digestive gland, the glandular first compartment may perhaps be regarded as its homologue as well as analogue.

Nervous System.—As in the adult *Lernæa*, there are no elements present which can be recognised as nervous.

Reproductive Organs.—The disposition of these organs is essentially similar in the two sexes. Paired reproductive glands are situated on either side of the anterior portion of the first compartment of the digestive tract; the glands are hollow, when not filled by reproductive cells, and communicate, without any intervening constriction, with oviduct or vas deferens. The situation of the external orifices has already been described.

The situation of the oviduct, which is the same as that of the vas, can be gathered by a reference to the diagram (Fig. 1), and the various figures of the transverse sections(Figs. 20 to 25). The oviduct presents two well-differentiated segments. The anterior, which is apparently uterus rather than oviduct, is of large lumen, is

lined by a flattened epithelium, and is usually distended with more or less matured ova. The posterior segment or oviduct proper is lined by a columnar epithelium (Fig. 29), is of small lumen or its walls are in contact, and does not contain ova. Extending anteriorly from the junction of the two segments is a short blind diverticulum, which *may* be a receptaculum seminis, but does not contain spermatozoa in any of my specimens (Fig. 1). For a portion of its course, the oviduct proper is freely open to a gland situated dorsal to it (Figs. 1 and 31), and which probably supplies the material which serves to agglutinate the ova into strings.

Just within the vulva are two bundles of plain muscle-fibres, which are capable of depressing the floor of the last portion of the duct. Their contraction possibly creates a vacuum which helps in the passage of the ova along the duct (Fig. 32).

The vas deferens is lined by a columnar epithelium (Fig. 28). Ventral to the digestive canal, there is a tubular connection between the two external male orifices. This tube may be a vesicula seminalis; it is lined by a synectial epithelium, and in its walls are a few plain muscle-fibres (Figs. 27 and 30).

Development.—The mature ovum is of the typical egg-shape, even to having a thicker and a thinner end; its subsequent history shows the thicker end to correspond to the posterior pole of the embryo. The nucleus is large; a chromatin network and nucleolus are plainly visible in a perfectly hyaline nucleoplasm. Yolk-spherules are plentiful, and are quite evenly distributed throughout the cytoplasm.

Cleavage.—The first and second cleavages are parallel to the long axis of the ovum, and at right angles to each other.

Figure 33 is drawn from a section made at right angles to the long axis, through an embryo in the two-cell stage. The nuclei in this and other early cleavage-stages (four- and eight-cell stages) are surrounded by areas of cytoplasm comparatively devoid of yolk-spherules; this area is probably traversed by achromatic astral rays that are too fine to be seen in my preparations. Fig. 10 is a drawing of the reconstructed two-celled embryo.

A section of the four celled-embryo is shown in Fig. 34, and the reconstructed embryo in Fig. 11.

Fig. 34 gives one the idea that there has been unequal segmentation; this, however, is due to the fact that the section is not absolutely at right angles to the long axis.

Cleavage next takes place twice successively at right angles to the long axis, resulting in the eight- and sixteen-cell stages.

In the sixteen-cell stage, the embryo still retains its egg-shape, though it has increased slightly in size, owing to the separation of the blastomeres to give rise to a blastocœl (Figs. 35 and 36). Fig. 37 is a longitudinal section through a compacted embryo, in which the blastocœl has not yet appeared.

The appearance of the embryo in the sixteen-cell stage is shown in Fig. 12.

The rotational movement of the polar blastomeres, which leads to the even capping of the poles, is well shown in Fig. 35.

The fifth cleavage is again parallel to the long axis, and results in the thirty-two celled embryo. The blastocœl has increased a good deal in size (Fig. 38).

There now follow two more total and equal cleavages, the first in the longitudinal plane, the second in the transverse plane. These cleavages result in the formation of the hollow blastula.

There next follows a cleavage which does not affect a few cells situated at the posterior pole, about eight in number. The blastula is further enlarged at this division by increase of the blastocœl.

The larger cells, at the posterior end, now divide actively, their daughter-cells being shed into the blastocœl, where they, in turn, divide, to give rise to a solid mass of small cells, more or less completely filling the blastocœl (Figs. 39, 40, and Fig. 14).

Meanwhile, the parietal cells have undergone further division, and the embryo has decreased in size.

In this stage, the embryo is a solid gastrula, gastrulation having been by a much modified involution. The blastopore is represented by a saucer-like depression at the posterior pole (Fig. 13).

Histogenesis and Organogeny.—In the hollow blastula, those eight cells, the budding of which is to give rise to the solid core of

the gastrula, stain a lighter colour with borax carmine, than do the remaining cells. Even in the sixteen-celled embryo, in some cases, the posterior quad has a lighter tinge than the other twelve, and almost invariably a certain number of the posterior cells of the sixty-four celled embryo take this lighter tinge. From these cells are derived the whole of the internal organs; they constitute an *endo-mesoderm* rudiment.

The embryo as we left it in the last section, therefore, consisted of a wall of ectodermal cells, at the blastopore, exposing cells of the endo-mesoderm rudiment, the main body of which form a solid core to the embryo.

Whether the ectoderm grows over, and closes the blastopore, or whether the endo-mesoderm remains exposed here even in the nauplius, I was unable to decide. Some sections appear to evidence one condition and others the other, so that I leave the matter unsettled, but with a decided inclination to assert that the former condition exists, *i.e.*, the blastopore is closed.

The cells of the solid endo-mesoderm core soon increase in size, more especially those around the central axis.

Meanwhile, the ectoderm cells of the anterior pole become so differentiated, that a cap of them take a darker stain from hæmatoxylin than the rest.

There next follows a fatty degeneration of certain of the more centrally-placed endo-mesoderm cells, resulting in a mass of fat globules. Fig. 41 represents the embryo just before the fatty degeneration has properly set in. Along with the fatty degeneration of some of the cells of the endo-mesoderm core, there is growth posterior-wards of the anterior cap of differentiated ectoderm, together with a bilaterally symmetrical disposition of the margin of the same; of this symmetrical disposition, the most obvious feature is a division on the ventral side in the midline, and a pair of capes, to use a geographical term, which project beyond the general outline on either side of the median bay.

A rearrangement, and differentiation of the endo-mesoderm cells next takes place, accompanied by an intensification of the bilaterality of the ectoderm, and the first appearance of the appendages, on either side of the "bay." (See Fig. 42.)

The rearrangement of the endo-mesoderm is complex, and effected so quickly that I can do little more than describe the result; but, first, let me say that the undifferentiated ectoderm-cells have become very thin and transparent, and they certainly overlie the large mesoderm-cells presently to be described; but, as already stated, I am unable to say whether the blastopore closes, though strongly inclined to say it does.

The first result of the differentiation of the endo-mesoderm appears at the posterior end; here, five cells on each side and three at the end, which form, as it were, a belt on a level with the mid-line, and lying immediately beneath the ectoderm, increase in size and take a deep stain from hæmatoxylin. Of the lateral cells, the fourth, on each side, counting from the front, is larger than the others, and these decrease in size on each side of it (Fig. 42).

Lying deeper in the embryo, dorsal to the belt just mentioned, and directly dorsal to the large cell, but nearer the sagittal plane, there is, on each side, another large cell, which differs from those composing the belt, in staining a very little more lightly (Fig. 42,g).

Meanwhile, certain of the cells of the core placed towards the posterior end, have grown in size, apparently at the expense of their neighbours; they have collected up the fat globules, and apparently aggregated to themselves the whole of them.

These cells take practically no stain; their ultimate position is shown in Figs. 45 and 46. As a reference to those figures will show, these cells are of large size and not numerous. They are so arranged that, did they not touch at their inner ends, they would bound a cavity. A few similar but smaller cells extend back from the larger ones, between the deeply staining cells of the mesoderm band.

Whilst these cells have been assuming the above proportions and situation, the endo-mesoderm, or, as their change now shows, more correctly, the mesoderm-cells of the anterior end have become modified into muscle-strands (Figs. 45 and 46). The brain has appeared as a darkly staining hyaline area, composed, it would seem, of four or five large cells.

Two eye-spots are present over the brain. Each of these is a granular elongated cell, one end coming to the dorsal surface and pigmented, the other, in contact with the brain. On either side of the brain dorsal thereto, there is a medium-sized cell, with coarsely granular contents, and taking borax-carminine stain deeply. These are evidently glandular, perhaps larval kidneys.

The darkly staining belt is doubtless a paired mesoderm-band. The two cells dorsal to them are also mesodermal, and in the nauplius occupy practically the same position, and have altered only in that they take the stain more deeply. They are probably the primordial germ-cells. Their stability through a period of complex changes in all other regions, was what first suggested this to me, and it has since occurred to me that they are situated one on each side of the archenteron, at what must ultimately become the anterior end, and slightly dorsal to the midline.

The large cells which have aggregated to themselves the fat of the degenerated mass, are doubtless the endoderm cells, and constitute a potential archenteron.

The origin of the brain and of the larval kidneys, is quite unknown to me from actual observation; though one might discuss their probable origin from analogy. It is, however, worthy of note that the cells of the larval kidneys are essentially similar to the adult subdermal glands described on page 675.

Though I have the stages of development fairly complete, (see Figs. 41-44), and although I have examined those specimens carefully, I am quite unable to describe a single phase in the formation of the muscles. The suddenness of their appearance is truly surprising; in one stage, no trace of muscle is visible; in what would otherwise appear to be a stage closely following, the whole of the muscles are present.

I have now described, as far as my material permits, the internal organisation of the Nauplius; it remains to describe, as far as is possible, the history of the external form and the appendages.

The embryo, until the appearance of the ectodermal cap, presents only an anterior pole (thinner), and a posterior pole (thicker), dorsal and ventral sides being indistinguishable. Very soon

after the appearance of the cap, there appears, on one side, a bay in its margin; this, as further changes show, is on the ventral side; it, therefore, gives us the second axis, and is the first appearance of the bilateral symmetry of the adult.

There now follows a slow dorsi-ventral compression, which probably reaches its maximum with the nauplius. Concurrent with this, there has been a broadening of the anterior end and a narrowing of the posterior end, so that, in some cases, the head-end becomes decidedly broader than the posterior end; this, however, is variable.

Meanwhile, the appendages have been assuming the forms depicted in Fig. 46.

At first (Fig. 42) the appendages appear as thickenings of the ectoderm, situated far forward on either side of the ventral bay in the ectodermal cap. Later they pass back, and the two posterior pairs exhibit already their future biramous character (Fig. 43). The eye-spots are also now apparent.

Fig. 9 is derived from a mutilated embryo of the stage of development of Fig. 43; but which of the two pairs of biramous appendages it represents, I have been unable to decide.

The external features of the nauplius are depicted in Fig. 46. As mounted in balsam and in glycerine-jelly, the little animal is of a yellow colour, transparent, showing the situation of the archenteron with its large intracellular fat globules, also the muscles, the mesoderm-cells and primordial germ-cells of the posterior end. At the anterior end, the eye-spots appear as small pigment-spots surrounded by a very clear hyaline area. The granule-laden larval kidneys are visible, but the brain not so.

No external openings are discernible, mouth and anus not having formed, but between the first two pairs of appendages is a curved prominence, which might be interpreted as a labrum. The whole nauplius is enclosed in a very delicate cuticle, the first exoskeleton, which extends beyond the body proper, or, rather, encloses the body loosely, as the perisarc to the coenosarc in a zoophyte.

The appendages are three pairs, anteriorly situated. The exoskeleton is smooth, and devoid of spines, so that the appendages

are, with the exception of the labrum, the only structures which break its even surface.

The antennules are uniramous, blunt-ended, two-jointed limbs. The blunt distal end of the second joint bears two long, stiff bristles.

The antennæ are biramous, composed of a single-jointed protopodite, and of two rami, each two-jointed. Both rami are blunt-ended, and bear each two bristles very similar to those of the antennules.

The mandibles differ from the antennæ only in being smaller, and in that the inner side of the last joint of the anterior ramus bears two or three of the long bristles, as well as the usual two on the blunt end.

This completes the account of the development, as far as I am able to take it; the stages between the nauplius and the adult, are probably passed through as a free-living period of the life-history. It, therefore, only remains to review this development, and to classify *Ubius*. Before passing to review the development, I would like once more to draw attention to the absence of the digestive gland, or rather to its occupying a very primitive embryonic situation, and to suggest that this may be found to be correlated with a very abbreviated ontogeny.

Review of the Development.—The cleavage is of Korschelt and Heider's first type (3, p. 108), characterised by them as being very rare among the Crustacea. This type of cleavage, however, occurs in two other copepods of which the development has been studied. I refer to *Cyclops* (2), and *Chondracanthus* (6). In both of these, not only is the cleavage total, but it follows very much the same lines as in *Ubius*. There may be a difference in the arrangement of the cells in the eight-cell stage in *Chondracanthus*.

In all these three copepods, invagination takes an almost identically similar form, which form reappears in *Lucifer* (1), though here toned down, as it were, and connecting the extreme modification of the above copepod type with typical embolic gastrulation, I am unable to find tissue-differentiation appearing at so early a stage in *Ubius* as Häcker was able to demonstrate in *Cyclops*. The

endo-mesoderm "*anlage*" is early recognisable, but only in the early nauplius-stage, does it become possible to separate endoderm and mesoderm.

It is worthy of note that histogenesis has not progressed so far in *Ubius* at the nauplius stage as in *Chondracanthus*. This difference is most striking at the posterior end. In *Ubius* the ectoderm is so extremely thin as to be actually doubtfully present at the extreme posterior end, whilst the mesoderm-belt is composed of not more than twenty-five large cells. In *Chondracanthus*, the ectoderm is so well developed that the rudiment of the ventral ganglion (Bauchganglienanlage) may be identified. Mesoderm and endoderm, however, are not so far advanced in differentiation.

Comparative.—A brief comparison with *Ive balanoglossi* Mayer, has already been made in the generic description; in view of their close relationship and similarity, it may be well to tabulate the outstanding differences.

Ive balanoglossi.

Body presenting annular thickenings, suggesting segmentation.

Oesophagus chitin-lined.

Mid-gut strongly muscular.

End-gut lined by chitin.

Double ventral nerve-cord.

Ovary single.

Testes large, reniform.

Ubius hilli.

Body cylindrical, without trace of segmentation.

Oesophagus lined by columnar epithelium.

Mid-gut devoid of obvious muscles.

End-gut absent.

No nerve-cord visible.

Ovary paired.

Testes small, cylindrical.

Systematic.—The systematic position of *Ubius* must remain more or less in doubt, until the stages between the nauplius and the adult are known; meanwhile, an attempt must be made to assign it a position on the characters of the adult. Notwithstanding the important differences between *Ive* and *Ubius*, it seems evident that they both belong to the same family. I agree with Mayer that it is not necessary to found a new family for the reception of *Ive*, but unlike him, I am unable to see that its adult features point to a relationship with *Lernæa*.

I fail to see much significance in the resemblance between the mouth-organs of *Ive* and those of the young *Lernæa*, nor am I able to see that the remaining appendages may be brought into line with those of *Lernæa*.

It appears to me preferable to class *Ive* and *Ubius* as members of the *Chondracanthidae*.

In *Chondracanthus*, the body is unsegmented but lobed, and the appendages are antennules, antennæ, mandibles, maxillæ, and two pairs of legs. In *Ive*, the body is unsegmented but lobed, and the appendages are antennules, antennæ, mandibles, and two pairs of legs. In *Ubius*, also, five pairs of appendages are present; and, in view of the general similarity between *Ive* and *Ubius*, one is justified in applying Mayer's identification to the appendages in this species also. So that the absence of maxillæ is the only feature which contra-indicates the classification suggested, when weighing external features for and against.

Mayer describes having found male *Ive* attached to the female, a phenomenon constantly presented by *Chondracanthus*.

The segmentation of *Ubius* presents a type rare among the crustacea, and is similar to that of *Chondracanthus*, differing completely from that in *Lernæa* (Korschelt and Heider, Pt.ii., p.117).

The unpaired genital gland in *Ive* is opposed to the classification here suggested, but holds equally strong as an objection to classifying the genus with *Lernæa*.

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EXPLANATION OF PLATES LXVIII.-LXX.

Plate lxviii.

- Fig. 1.—Diagrammatic representation of the arrangement of the internal organs: *a*, mouth—*b*, ovary—*c*, uterus—*d*, receptaculum seminis(?)—*e*, oviduct—*f*, vulva—*g*, slime-gland—*h*, solid posterior end of gut.
- Fig. 2.—Anterior third of a female specimen: *a*, mouth—*b*, œsophagus—*c*, endoskeletal rod of chitin—*d*, antennule—*e*, antenna—*f*, mandible—*g*, *h*—legs.
- Fig. 3.—Posterior third of a female specimen: *a*, vulva—*b*, genital appendages—*c*, slime-glands—*d*, posterior end of gut.
- Fig. 4.—Outline of a male specimen.
- Fig. 5.—Antennule.
- Fig. 6.—Antenna.
- Fig. 7.—Mandible.
- Fig. 8.—First leg.
- Fig. 9.—Antenna or mandible, from an embryo about the same stage of development as that represented in Fig. 43.
- Fig. 10.—The two-celled embryo.
- Fig. 11.—The four-celled embryo.
- Fig. 12.—The sixteen-celled embryo.
- Fig. 13.—The gastrula.
- Fig. 14.—Showing evidence of rapid division of the endomesoderm anlagen during gastrulation(*cf.* Fig. 39).

Plate lxix.

- Fig. 15.—Transverse section at the level of the oral cavity: *a*, œsophagus—*cav.*, oral cavity.
- Fig. 16.—Longitudinal section in the region of junction of œsophagus and first compartment.
- Fig. 17.—A subdermal gland.
- Fig. 18.—Transverse section just in front of the ovaries.
- Fig. 19.—Epithelium of the anterior portion of the first compartment.
- Fig. 20.—Transverse section at the level of the ovaries: *Or.*, ovary—*ut.*, uterus.
- Fig. 21.—Transverse section at the level of the posterior end of the first compartment.
- Fig. 22.—Transverse section at the level of the second compartment: *gl.*, digestive(?) gland.
- Fig. 23.—Transverse section at the level of the junction of uterus and oviduct(*ovd.*).
- Fig. 24.—Transverse section at the level of the posterior end of uterus and commencement of the oviduct(*ovd.*).

- Fig. 25.—Transverse section at the level of the posterior end of the alimentary canal(*al.*).
- Fig. 26.—Two cells from the digestive(?) gland related to the second compartment.
- Fig. 27.—Transverse section at the level of the external orifice of the vas deferens(*ap.*) and the vesicula seminalis(*v.s.*).
- Fig. 28.—Vas deferens in transverse section.
- Fig. 29.—Epithelium of the oviduct.
- Fig. 30.—Portion of the section drawn in Fig. 27, under higher magnification: *vas.*, vas deferens.
- Fig. 31.—Transverse section at the level of the vulva(*v.*) on one side: *s.gl.*, slime-gland.
- Fig. 32.—The region of vulva(*v.*) *Mus.*, plain muscle-bundles.

Plate lxx.

- Fig. 33.—The two-celled embryo, transverse section.
- Fig. 34.—The four-celled embryo, transverse section.
- Fig. 35.—The sixteen-celled embryo, transverse section.
- Fig. 36.—The sixteen-celled embryo, longitudinal section.
- Fig. 37.—The sixteen-celled embryo, longitudinal section.
- Fig. 38.—The thirty-two-celled embryo, transverse section.
- Fig. 39.—The gastrulation period of development, longitudinal section.
- Fig. 40.—The gastrulation period of development, transverse section.
- Fig. 41.—Longitudinal coronal section of the late gastrula.
- Fig. 42.—The very early nauplius(*A'*, antennule; *A''*, antenna; *mn.*, mandible; *mes.*, mesoderm; *g.*, primordial germ-cell).
- Fig. 43.—A more advanced nauplius(*e.*, eye).
- Fig. 44.—The nauplius(*lbr.*, labrum).
- Fig. 45.—The nauplius, nearly median coronal section(*oc.*, retinal cell; *br.*, brain; *nph.*, larval kidney).
- Fig. 46.—The nauplius, median sagittal section(*end.*, endoderm; *mus.*, skeletal muscles).